APPENDIX II

SAMPLE GROUTING LOG

1. In the grouting log (fig. II-1), the inspector has collected pertinent information from the drilling and pressure testing records and knows that he is going to grout zone 4 of a primary hole, that the hole is inclined 25 deg from the vertical, that the top of the zone to be grouted is 68 ft vertically below the surface, that the hole was pressure-tested at the rate of 0.5 cfm at 10 psi, and that the top of zone 4 is below the water table. From figure 4 (main text), he finds that pressures exerted by grout columns of 2:1 and 1:1 grout 1 ft high are 0.61 and 0.73, respectively. Grout columns of these mixes 68 ft high would exert pressures of about 42 and 49 psi. This means that if 1:1 grout is used, the maximum gage pressure should be 19 psi so that the total pressure at the top of zone 4 will not exceed 68 psi (1 psi per foot of vertical depth).

2. The inspector decides to start with 4:1 grout, although 3:1 grout would be an acceptable starting mix considering the pressure-test results and the fact that all of zone 4 is below the water table. After the header is in place with the valve to the hole closed and the valve on the return line open and the contractor is ready to begin grouting, the inspector asks for a three-sack batch of 4:1 grout. This should be enough to find out if the hole will take grout. (A two -sack batch would make little more than enough to cover the suction intake to the pump and fill the pump and grout lines.) A three -sack batch of 4:1 grout will make 13.5 cu ft since a sack of cement (94 lb) has a volume of only O.5 cu ft when immersed in water. The volume of each batch mixed is entered under the heading ‘ ‘Grout, Cu Ft. ” Note that the first entry in the column headed “Tank Reading” shows 12.0 cu ft of grout in the sump tank. This reading is made after the grout has been circulated through the pump and grout lines. The difference between 13.5 cu ft and 12.0 cu ft is the amount of grout required to fill the pump and lines. After circulating the grout and getting the tank reading, the inspector is ready to start grouting. The valve to the hole is opened and the valve on the return line is closed as required to divert grout into the hole at the pressure designated.

3. Pressure can be obtained as desired without completely closing the return line. The inspector asks that it be held to 10 psi while he determines the rate of injection. He does this by measuring the amount of grout in the tank after 5 min of pumping with a stick gage calibrated to read in cubic feet for that particular tank. He finds that 9.5 cu ft of grout remain in the tank. ‘ Thus, 2.5 cu ft of grout were pumped into the hole during the first 5 min of grouting, which gives a rate of 0.5 cfm. Usually the rate of injection, shown in the seventh column on the sample log, is computed on batch quantities, assuming that the level of grout in the sump tank is the same each time a new batch is discharged from the mixer. More frequent observations on the

Hole No. 23-2, Primary Sta. 23+20
Zone 4 Axis El. 564.4
75'-100'; Inc. 25°

Date: 6/21/62 Water table about 20'
Shift: 1600-2400 hrs Press. test: 0.5 c'm @
Inspector: J. Jones 10psi 6/19/62

Time	Mix	Cement Sacks	Grout Cu. ft	Tank Reading	Gage Pressure	Grout cu.ft/min	Cement cu.ft/hr	Remarks
1738	4:1	3	13.5	120 cu. ft.	0			Started grouting at 1738 hrs
1743				9.5	10	0.5		Vertical depth to Zone 4 is 68'
1751		2	9.0		15	0.75	10.0	Add 42psi for 2:1 & 49 psi
1803	3:1	3	10.5		15	0.8	13.8	for 1:1. Add 38 psi for
1816		3	10.5		15-0	0.9	15.0	3:1 grout. Delay 1828 -
1830		3	10.5		0-15	0.9	15.0	1830 hrs. Water line broken
1842		3	10.5		20	0.95	16.4	1810 hrs. Repaired at
1853	2:1	3	7.5		20	0.9	22.5	1828 hrs. Pressure at 0
1901		3	7.5		20	0.9	22.5	during delay.
1909		3	7.5		20	0.9	22.5	
1917		4	10.0		20	0.9	21.8	
1928		4	10.0		25	0.9	21.8	Checked area for leaks at 1845
1939		4	10.0		26	0.8	19.2	" " " " " 1945
1951.5		4	10.0		26	0.75	17.8	
2005		4	10.0		26	0.5	11.4	
2026	3:1	3	10.5		27	0.75	12.9+	
2040		3	10.5		30	0.6	10.6	
2057		3	10.5		30	0.5	9.1	
2117		3	10.5		30	0.35	6.0	
2147		2	7.0	4.5+7.0	30			
2152				10.8		0.14		
2157				10.6		0.04		Completed grouting at 2157 hrs.
		60.0		1.5	(line & pump)			
		3.5		12.1	Carried			
		56.5			forward			

Figure II-1. Sample grouting log

rate of injection can be made, if desired, by using the stick gage to measure the amount of grout pumped during any given time interval. The inspector may want to check the rate just before changing mixes to be sure that the last computed rate is continuing. Such observations may be recorded or not as the inspector wishes. According to the log the hole accepted 4:1 grout readily, so it is understandable that a thicker mix should be tried. The thicker 3:1 grout increased the rate of cement injection, although not as much as shown for the first batch. The first batch of a thicker new mix dumped into the remnants of the old mix is diluted. In this case the 10.5 cu ft of the 3:1 mix was diluted by about 6.0 cu ft of 4:1 mix remaining in the tank and circulating through the pump system. This dilution would give a mix of about 3.3:1 and a cement-injection rate for the first batch of 12.7 cfm rather than 13.8 as shown. The only time it is necessary to make this computation is at the completion of grouting if the new mix has not been used long enough to have its "as -mixed" proportions in the sump tank.

4. A delay of 2 min (1828-1830 hr) occurred as the result of a broken water-line. The water for the batch of grout discharged at 1816 hr was in the mixer when the line was broken, otherwise the delay would have been 12 min longer, since the line was broken 6 min before the batch was needed. It is good practice to charge the mixer with the water for the next batch immediately after discharging. This helps to keep the mixer clean and provides a small supply of water for emergency use.

5. After a few batches of 3:1 grout, it appeared that the hole would accept a thicker grout and the inspector changed the mix to 2:1 grout. The change from 3:1 to 2:1 grout causes a much greater increase in the rate of cement injection than changing from 4:1 to 3:1 grout. The inspector should carefully observe the effect of a change to a thick or moderately thick grout on the injection rate. In the case of the sample log there was some evidence of a reduction in rate 'after four batches. In reality it was not until the third batch of 2:1 grout that the hole was actually receiving 2:1 grout because of the diluting effect of the 3:1 grout left in the system when the 2:1 grout was introduced. The first evidence of a slowing rate of injection appeared in the fifth batch of 2:1 grout, which was dumped into the sump tank at 1928 hr. Despite the increase in pressure, the injection rate was the same as for the preceding batch with less pressure. It is probable that the inspector was aware of this slowing and raised the pressure as a consequence of it. The rate continued to decrease even with the pressure at the maximum allowable (26 psi on the gage and an additional 42 psi by weight of the grout column). The average rate of injection for the last batch of 2:1 grout mixed (2005 hr) was 0.5 cfm. It is probable that the rate at the end of the 24-min period of injection for this batch was about 0.3 cfm, although this was not recorded. Thus, there was reason to think that one more batch of 2:1 grout would finish the hole. Therefore, the mix was thinned toward the end of prolonging the grouting period and injecting additional cement. The gage pressure was raised to compensate for the reduction of pressure from the lighter weight

column of grout. Grouting was considered complete when the injection rate for the 3:1 grout dropped below 0.1 cfm for a 5-min period. This rate was determined by measuring the amount of grout in the sump tank at the beginning and end of the period.

6. The last tank reading shows that 10.6 cu ft of grout was left in the tank when the hole was finished, and the first tank reading indicated that 1.5 cu ft of grout was in the lines and pump. These two quantities together make 12.1 cu ft of 3:1 leftover grout. Since 12.1 cu ft of 3:1 grout contains approximately 3.5 sacks of cement, that number of sacks must be subtracted from the total number mixed for this hole to obtain the number of sacks (cubic feet) of cement actually in the hole. The 12.1 cu ft is carried forward to the next hole and would be a first entry in the log of the new hole if started with 3:1 grout. If the new hole should be started with 4:1 grout, 3.5 cu ft of water would be added to the leftover grout to make 15.6 cu ft of 4:1 grout.

7. A review of the pressures and injection rates recorded in the sample log reveals no sudden changes or abnormalities. The log contains no evidence of lifting or leakage. Minor fluctuations of rate would appear if the entries were not rounded off. to the nearest 0.05 cu ft. The fluctuations are most often caused by recording time to the nearest half minute only. The increase of pressure by increments permits direct observation of the effect of each pressure change. This is particularly important in stage grouting because it is the practice to apply pressures to surface rock that in other situations could only be used for rock under heavy confining loads. If the grouting pressure in the sample log had been raised from O to 30 psi as fast as possible, the inspector, without visible evidence of lifting such as heaved rock or surface breakouts, would not have any way to be certain that lifting was not taking place.

8. If an additional column is needed on this log form to record quantities of filler or admixture in the grout, it can be provided by moving columns beginning with "Grout,, Cu Ft" to the right into the "Remarks" space. A second additional column can be made available by recording the ' 'Tank Reading" data under "Remarks. "